Table 5.—*Average daily total radiation (direct and diffuse) received on a horizontal plane in gr. cal. per square centimeter*

	New Orleans, La. (lat. 29°56′ N; alt. 100 feet)			Gainesville, Fla. (lat. 29°39′ N; alt. 233 feet)			Miami. Fla. (lat. 25°41′ N)			La Jolla, Calif. (lat. 32°50′ N; alt. 85 feet)			Fresno, Calif. (lat. 36°43′ N; alt. 330 feet)			Washington, D. C. (lat. 38°56′ N; alt. 414 feet)		
	1932	1933	Average	1932	1933	Average	1932	1933	Average	1932	1933	Average	1932	1933	Average	1932	1933	Average
Jan. 1-28	157	171	164	242	130	186	344	275	310	278	214	246	210	148	179	143	179	161
Jan. 29-Feb. 25	194	199	197	233	178	205	409	356	383	291	287	239	322	327	325	212	268	240
Feb. 26-Mar. 31, 1932 / Feb. 26-Apr. 1, 1933	276	299	288	432	431	432	472	438	455	384	346	365	441	455	447	332	347	340
Apr. 1-28, 1932 / Apr. 2-29, 1933	370	338	354	545	414	435	534	430	487	481	341	411	558	389	474	473	445	459
Apr. 23-June 2, 1932 / Apr. 30-June 3, 1933	315	456	386	546	539	543	492	509	501	557	412	481	653	444	549	512	459	486
June 3-July 1, 1932 / June 4-July 1, 1933	404	511	458	507	465	486	526	539	533	442	397	420	729	714	722	489	582	536
July 2-29	359	349	354	536	395	461	584	498	541	409	329	369	714	706	710	528	517	523
July 30-Sept. 2	288	373	331	262	404	333	465	475	470	342	411	372	645	635	610	540	445	493
Sept. 3-30	347	403	378	222	381	302	436	494	465	232	324	278	498	556	527	441	358	400
Oct. 1-28	346	348	347	204	302	253	397	377	387	220	277	249	421	413	417	277	319	298
Oct. 29-Dec. 2	246	254	250	132	275	203	314	339	327	238	320	279	290	300	295	227	185	206
Dec. 3-31	116	213	165	110	247	178	275	311	293	198	260	229	168	153	161	147	134	141
Average	284	322	303	331	346	339	437	421	429	339	326	333	471	437	454	360	353	357
Total (average times 365)	103,660	117,530	110,595	120,815	126,290	123,552	159,505	153,665	156,585	123,735	118,990	121,363	171,915	159,505	165,710	131,400	128,845	130,305

	Pittsburgh, Pa. (lat. 40°32′ N.; alt. 1,114 feet)			New York, N. Y. (lat. 40°46′ N.; alt. 156 feet)			Lincoln, Nebr. (lat. 40°50′ N.; alt. 1,250 feet)			Chicago, Ill. (lat. 41°47′N.; alt. 688 feet)			Twin Falls, Idaho (lat. 42°29′ N.; alt. 4,300 feet)			Madison, Wis. (lat. 43°05′ N.; alt. 1,009 feet)		
	1932	1933	Average	1932	1933	Average	1932	1933	Average	1932	1933	Average	1932	1933	Average	1932	1933	Average
Jan. 1-28	94	113	104	96	145	121	177	201	189	85	119	102	159	160	160	100	131	116
Jan. 29-Feb. 25	161	180	171	191	211	201	257	315	285	167	203	185	261	263	262	209	227	218
Feb. 26-Mar. 31, 1932 / Feb. 26-Apr. 1, 1933	235	201	213	291	269	280	375	364	370	236	221	229	311	369	340	326	264	295
Apr. 1-28, 1932 / Apr. 2-29, 1933	360	343	352	421	365	393	390	460	425	393	359	378	436	385	417	430	354	392
Apr. 29-June 2, 1932 / Apr. 30-June 3, 1933	470	337	404	507	412	460	529	500	515	455	403	429	513	536	525	466	423	445
June 3-July 1, 1932 / June 4-July 1, 1933	500	502	501	490	545	518	541	637	589	518	526	522	596	582	589	532	563	548
July 2-July 29	509	458	434	567	463	535	580	599	590	549	556	553	597	605	601	570	522	546
July 30-Sept. 2	449	390	420	472	382	427	455	443	449	433	457	440	572	564	568	432	489	461
Sept. 3-30	377	274	346	380	309	345	429	416	424	378	295	337	461	462	462	397	319	358
Oct. 1-28	218	213	216	211	269	210	304	363	334	211	239	225	310	364	337	197	250	224
Oct. 29-Dec. 2	132	124	128	175	160	168	215	228	222	113	146	130	181	232	207	132	150	141
Dec. 3-31	79	80	80	119	92	106	187	175	181	110	76	93	163	143	153	119	99	109
Average	299	268	284	328	302	315	370	392	381	304	300	302	380	389	385	327	316	322
Total (average times 365)	109,135	97,820	103,478	119,720	110,230	114,975	135,050	143,080	139,065	110,960	109,500	110,230	133,700	141,935	140,340	119,350	115,340	117,345

THE CRITICAL PERIOD OF CORN IN NORTHEASTERN KANSAS

By A. D. Robb

[Weather Bureau office, Topeka, Kans., July 1934]

This paper is an endeavor to correlate rainfall and the yield of corn in northeastern Kansas, to determine when rain is of the most value and what effect it has on the crop in this section.

The 11 counties, Marshal, Riley, Nemaha, Jackson, Pottawatomie, Brown, Doniphan, Atchison, Jefferson, Leavenworth, and Wyandotte comprise the area for this study. They are the chief corn-producing counties of the State. Statistics of crop yields and precipitation data used are both official, one being obtained from the Bureau of Agricultural Economics and the other compiled by the Weather Bureau. The period used was the 33 years, 1901 to 1933, inclusive.

The method used is familiar and there is no need to explain it here, except to reiterate the fact that the nearer the correlation coefficient, r, approaches 1 the closer the relation, and the nearer it approaches 0 the less the relation. Some writers believe that the influence of one factor upon another is well established if the correlation coefficient is 3 times the probable error, while others think that it should be 6 times that value. It is better to assume that there may be some connection if the correlation coefficient is 3 times the probable error and that the relation is established beyond question if it is more than 6 times that error. Correlation coefficient tables have been worked out according to this method for the 33-year period in northeastern Kansas, first for calendar months and then for other periods.

Table 1.—*Relation between rainfall and corn yields in northeastern Kansas by months, 1901-33*

Period of rainfall	Correlation coefficient, r	Period of rainfall	Correlation coefficient, r
May	+0.01	September	+0.05
June	+0.30	June and July	+0.61
July	+0.58	July and August	+0.80
August	+0.51	June, July, and August	+0.74

The value of r for July is nearer the whole number 1 than that of any other single month. However, it is followed very closely by that of August, indicating that the rainfall of July is of greater effect in producing a corn crop than any other single month and that the rainfall of August is also of great value. In the combination of months only the 3 months with the greater values of r were used. The rainfall of July and August is of far greater influence than that of June and July, or even of the 3 months, June, July, and August.

Since the June value for r is so much smaller than that for July it seems that rain the first part of July probably does not have a great deal of influence on the final yield, and a like argument applies to the last of August. To determine this question, the value of r was worked out for shorter periods than months. The first is for 10-day periods.

TABLE 2.—*Relation between rainfall and yield of corn in northeastern Kansas for 10-day periods, 1901–33, and the average precipitation for each period*

Period of rainfall	Correlation coefficient r	Average precipitation (inches)
July 2–11	+0.23	1.5
July 12–21	+.51	1.1
July 22–31	+.30	0.9
Aug. 1–10	+.44	1.5
Aug. 11–20	+.24	1.4
Aug. 21–30	+.22	1.0

July 12–21 has the highest value for r of any of these periods, with a probable error of ±0.09, which is about one-sixth of the value for r. This establishes the fact that rainfall in this period is an important determining factor in the yield of corn. The value of r for the period July 12–21 is followed by a comparatively low one of +0.30 for July 22–31, and that by a higher one of +0.44 for August 1–10. The explanation of this may be found in the average precipitation for these periods. The period July 2–11 has 1.5 inches of rain, July 12–21, 1.1 inches, and July 22–31 only 0.9 inch, and the first 10 days of August 1.5 inches.

From the Weekly Weather and Crop Bulletin of past years July 14 was found to be the average date of tasseling in this area, which is in the period of the highest value for r. This date is also so near the period of the greatest average rainfall that the influence of the rains earlier in the season is still felt.

Also, it may be that 10 days is not a long enough drought to damage the corn seriously, especially if followed immediately by good rains. The year 1917 illustrates this very well. During the month of July the average precipitation for this section of Kansas was only 0.78 inch, with corresponding high temperatures. An excerpt taken from the Climatological Data for Kansas, July 1917, states, "Corn * * * was badly damaged by the high temperatures, excessive sunshine, and hot winds of the last decade." Rains began the first day of August and the average over this area for the first 10 days of August was 2.65 inches. The sequel to the statement of the effect of the July weather on corn is taken from the August 1917 number of Climatological Data: "The revival of crops after the rains began was almost magical. The corn crop took on new growth * * *." The average yield in this section was 25.8 bushels per acre, just 0.5 bushel above the average.

The highest value for r in table 3 is +0.61 for the 20 days July 22 to August 10, which is nine times the probable error and shows very clearly the effect of rain on corn during this time. The average date of tasseling is not in the period of highest correlation value in this table, but does fall in the one of next highest value, July 12 to 31, which is only a few points lower.

TABLE 3.—*Relation between rainfall and yield of corn in northeastern Kansas for 20-day periods, 1901–33*

Period of rainfall	Correlation coefficient r	Period of rainfall	Correlation coefficient r
July 2–21	+0.39	Aug. 1–20	+0.44
July 12–31	+.54	Aug. 11–30	+.32
July 22–Aug. 10	+.61		

The 30 days July 12 to August 10 has the highest value for r, and is 11 times the probable error. It is also higher than any other values for r in any of the other periods except for the combination of the months of July and August, and June, July, and August in table 1. While the calendar months are of practically the same number of days, in no single month does the value of r approach very close to the value of r in the period of July 12 to August 10.

TABLE 4.—*Relation between rainfall and yield of corn in northeastern Kansas for 30-day periods, 1901–33*

Period of rainfall	Correlation coefficient r	Period of rainfall	Correlation coefficient r
July 2–31	+0.58	July 22–Aug. 20	+0.60
July 12–Aug. 10	+.69	Aug. 1–30	+.52

A line graph was made of the precipitation of the 30-day period July 12 to August 10, comparing it with the average yield for each of the 33 years, 1901–33, figure 1. This shows a very great dependence of the resulting corn yield on the precipitation of this period.

A bar graph of the precipitation of this 30-day period and the average corn yield was also prepared, figure 2. The precipitation was arranged in order of amounts beginning with the lowest. It is very evident that in some cases there are other factors outside the rainfall of the period July 12 to August 10 that influence the yield of corn. The most notable is the comparison of the years 1901 and 1902. There was almost the same amount of rain in the 30 days of 1901 as there was in the corresponding time of 1902 but the yield was in no way comparable. The period of July 12 to August 10 of 1901 was preceded by a hot dry June and excessively hot weather the fore part of July. The rains did not come till near the close of July. The same period of 1902 was preceded by a June of abundant rainfall and good rains also during the first of July. The corn crop was damaged beyond recovery by the hot, dry weather of June and July in 1901 before the rains came.

In the 18 years that the precipitation of this 30-day period has been below the average, only 5 have resulted in a crop above the average. In the 15 years when the precipitation has been above the average only once has the resulting yield of corn been below the average.
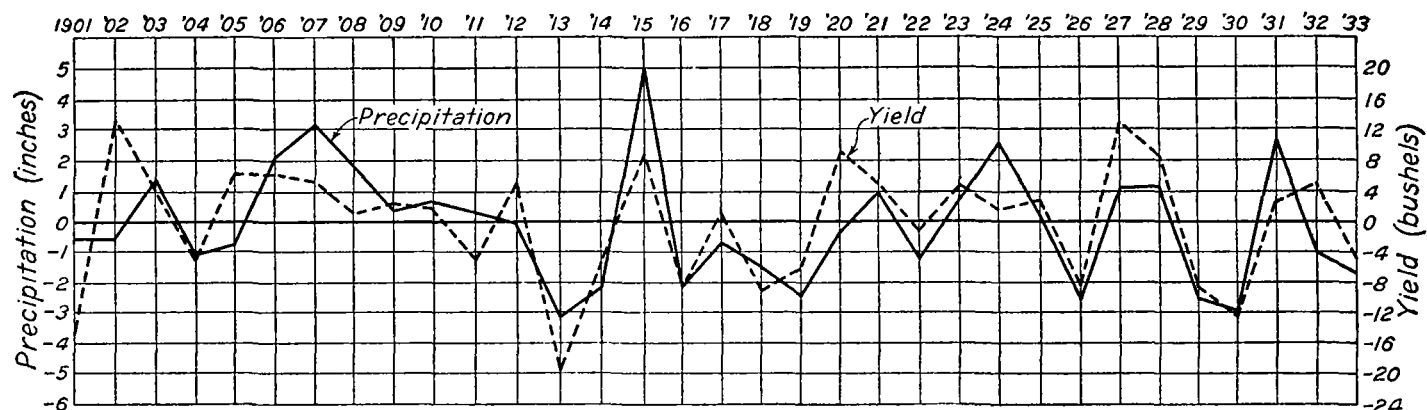
FIGURE 1.—Line graphs of precipitation of the 30-day period July 12 to August 10, compared with the average corn yield, 1901–33.
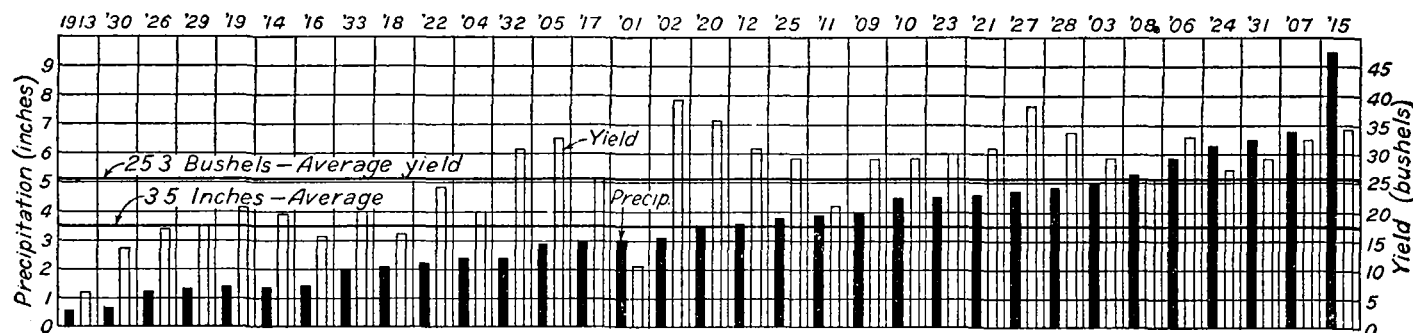

FIGURE 2.—Bar graph of the precipitation for northeastern Kansas for the period July 12 to August 10, arranged in order of amounts, compared with the average corn yield, for the years 1901–33.

TABLE 5.—*Average precipitation, July 12 to August 10, 1901–33 over northeastern Kansas, grouped according to amounts and compared with the average yield per acre*

Year	Average precipitation	Average yield in bushels per acre	Year	Average precipitation	Average yield in bushels per acre
1913	0.4	5.6	1911	3.8	20.8
1930	.6	14.3			
Total	1.0	19.9	Total	23.6	192.5
Average	.5	10.0	Average	3.4	27.5
			1909	4.0	28.5
1926	1.1	16.8	1910	4.3	28.4
1929	1.2	17.6	1923	4.3	30.0
1919	1.3	20.2	1921	4.5	30.5
1914	1.4	19.0	1927	4.7	38.0
1916	1.4	16.1	1928	4.7	33.8
Total	6.4	89.7	Total	26.5	189.2
Average	1.3	17.9	Average	4.4	31.5
1933	2.0	20.0	1903	5.0	29.0
1918	2.1	16.3	1908	5.3	26.0
1922	2.2	24.3	1906	5.8	33.5
1901	2.4	20.4			
1932	2.4	31.4	Total	16.1	88.5
1905	2.9	33.2	Average	5.4	29.5
Total	14.0	145.6	1924	6.2	27.6
Average	2.3	24.3	1931	6.2	28.9
			1907	6.7	32.5
1917	3.0	25.8			
1901	3.1	11.0	Total	19.1	89.0
1902	3.1	39.5	Average	6.4	29.7
1920	3.4	35.2			
1912	3.5	31.3	1915, total	8.5	34.6
1925	3.7	28.9			

This table shows how much the yield of corn in northeastern Kansas is dependent on the rainfall of July 12 to August 10. On the average if there is less than an inch of rain in that time the yield will be about 10 bushels. If there is from 1 to 2 inches the yield is increased to 18 bushels. When there is between 2 and 3 inches of rain the yield is further increased to about 24 bushels per acre. When there is from 3 to 4 inches of rain the yield

is increased further by only 4 bushels per acre. If there is between 4 and 5 inches of rain the yield is again increased about 4 bushels per acre, making an average yield of 32 bushels. Six years have had between 5 and 7 inches of rain and the yield dropped to about 30 bushels per acre on the average. One year had 8.5 inches of rain in this period and the average yield that year was 35 bushels per acre. In general, the more rain there is in the 30-day period July 12 to August 10 in northeastern Kansas the greater the resulting yield of corn.

TABLE 6.—*Time of planting of corn and the departure from the average yield for 20 years*

	Departure from average yield	
Years corn was planted on or before May 4:		
1901		−14.7
1902	+13.8	
1903	+3.3	
1905	+7.5	
1920	+9.5	
1921	+4.8	
1922		−14.7
1923	+4.3	
1924	+1.9	
1925	+3.2	
1926		−8.9
Years corn was planted after May 4:		
1904		−5.3
1919		−5.5
1927	+12.3	
1928	+8.1	
1929		−8.1
1930		−11.4
1931	+3.2	
1932	+5.7	
1933		−5.7

The data of table 6 were compiled from the Weekly Weather and Crop Bulletins for Kansas. It is the nearest approach to the time of planting that could be found for this section and covers the years 1901–05, and 1919–33, inclusive.

The average date of planting corn was found to be May 4. Corn has been planted on or before May 4, 11 times and after that date 9 times out of the 20 years used in this comparison. Eight of the eleven years when corn was planted on or before May 4 gave yields above the average and 3 below. In the 9 years that corn was planted after May 4, the crop was above the average four times and below five times. By planting corn in this section before May 4 there is an advantage of 3 to 1 that the crop will average 25 bushels or more per acre, while if it is planted after May 4 the chances of a normal crop or more is less than 50 percent.

The reason for this is found by reference to table 2. The time of tasseling of the corn crop was determined from the Weekly Weather and Crop Bulletin the same way that the date of planting had been, and was found to be about 70 days after the date of planting. Seventy days after planting, or May 4, is July 13, just 2 days after the period of the higher average of rainfall of July.

If corn is planted after May 4 the tasseling period comes in the drier periods of the latter part of July. The correlation coefficient for the period July 12–21 was +0.51, the highest value of any of the 10-day periods. The coincidence of the high value of r for this period with the average date of tasseling indicates that the tasseling period is the most critical in the life of the corn plant.

The conclusions are:

(1) The tasseling period is the most critical period of the corn plant's life.

(2) The average date of tasseling in northeastern Kansas is July 14.

(3) Two and one-half inches, or more, of rain near the tasseling period practically insures a crop of 25 bushels per acre.

(4) The latter part of July is, on the average, drier than the earlier part.

(5) Corn planted before May 4 usually reaches the critical period of its life before the dry weather begins.

DIURNAL VARIATION IN THE DEW-POINT TEMPERATURE AT ASHEVILLE, N. C.

By Leland T. Pierce

[Weather Bureau office, Asheville, N. C., July 1934]

Dew-point temperature is a direct index of the amount of moisture in the air, and therefore is subject to a number of practical applications in the identification of air masses and in forecasting. It is of particular value in the prediction of minimum humidities, and in this role is especially important in the preparation of fire-weather forecasts such as are issued in this fire-weather district no. 8. Its value in this work has prompted the investigation of its diurnal variations, since a forecast of the minimum humidity for the day must be based upon its anticipated level at the time of the maximum temperature, as varying from the 8 a. m. figure.

The premise upon which forecasting of minimum humidity was initiated in this district assumes that there is little regular diurnal variation in the moisture content of the air, except as induced by changes in the air mass. However, it has been found by experience that dew points do change very materially throughout the day. It is plain, then, that if the diurnal variation both as to direction and amount can be allowed for under varying conditions, it will be possible to make more accurate forecasts of the minimum humidity. To determine this variation, it has been necessary to summarize a large amount of data, thereby balancing out changes incident to storm movement and local factors.

Progress in this work was beset with many difficulties other than the large amount of routine work involved. First, it was realized that a number of variables can and do have a definite effect upon the dew-point, such as air-mass changes, the effect of seasonal changes in transpiration from forest areas, and a multiplicity of local variants, most of which cannot be measured. The most disconcerting was lack of faith in the absolute accuracy of psychrometer readings. It is well known that the human element bulks large in determining the accuracy of psychrometer observations, as does the condition of the muslin on the wet bulb. Cases have been seen on this station

when the dew-point figure has been lowered as much as 12 degrees simply by putting on a clean muslin. It is evident, too, that the errors due to personal inaccuracy and dirty wet bulbs are all in the same direction, and therefore are not self-compensating. However, fully realizing these inherent weaknesses of psychrometer readings, the work was necessarily conducted on the assumption that all original data are correct. Furthermore, it is believed that air masses, no matter how large, are by no means strictly homogeneous as regards moisture content. In consideration of these and other possible difficulties, records were taken for several years that extended over a period when observations were made consistently by the same two men.

It was assumed at the outset, and conclusions reached in this study verify the assumption, that cloudiness and wind direction, more than any other factors, have a bearing upon diurnal changes in the dew point. Therefore, dew points were classified according to occurrence on cloudy or on clear to partly cloudy days. This division into two classes only was made with the idea of keeping the routine work at a minimum, but it has since been concluded that a more detailed cloudiness classification should have been made. Figures were available, of course, for 8 a. m., local noon and 8 p. m. E. S. T., and in the tabulation the wind direction was included with each dew point, as was the prevailing direction for the day. The period of record covered was 1926 to 1932, inclusive. In order to suit the uses to which the data are to be put, noon and 8 p. m. dew points have been expressed in terms of departure from the 8 a. m. value. Emphasis has been placed upon the variations between morning and noon because this is the period of greatest importance in fire-weather forecasting. The first portion of this report deals with a recitation of facts concerning changes and trends, the explanation therefor being reserved for a later section.